MIT Sea Grant
SUMMER 1980

# Quarterly Report



## MIT Sea Grant 1980-1981

Commencing in July, with support from the National Oceanic and Atmospheric Administration, MIT and various government groups and business organizations, the MIT Sea Grant Program enters its eleventh year. In this Quarterly Report summer issue, we have sketched the objectives of each research, education and advisory service project as an index to the Program's current efforts.

Each year our focus changes slightly reflecting emerging technologies, crossed frontiers of knowledge, and the needs of Sea Grant's constituents in the marine community. In every instance, we are striving toward the integrated efforts of academia, industry and government to make maximum and beneficial uses of manifold ocean and coastal resources.

Sea Grant is an applied research program that depends on the input of the people who will be using the results. It is our hope that this and subsequent Quarterly Reports encourage questions, suggestions and participation.

## The Coastal Zone

Balancing immediate human needs with long-term ecological effects in the coastal zone is a delicate and critical problem. Fortunately, strides in computer technology are making it possible to forecast the impact of growth and development so that resources can be used without being used up.

Population increases can put too much pressure on peninsular and island aquifers, with resulting saltwater contamination of freshwater supplies. A saltwater intrusion model created by Department of Civil Engineering researchers predicts the effects of water use on a total aquifer. When completed in 1981, the model, known as SWIM, will help hydrologists monitor freshwater supplies and help communities select those development schemes with economic benefits and environmental safeguards.

Nutrients circulated and distributed in a coastal salt marsh by tidal action enrich plant roots and increase overall plant productivity. Toxic pollutants, such as oil discharges and chemical wastes, move in the same pattern but with potentially adverse effects on the ecosystem. To study the positive and negative impact of wastewater disposal or marsh fertilization programs, Sea Grant Civil Engineering researchers and Woods Hole Oceanographic Institution (WHOI) researchers are devising a tidal transport model. Combining field studies with computation, they are quantifying an estuary's capacity to use nutrients and absorb pollutants.

Occasionally eelgrass, a plant of significance in the marine food chain, inexplicably browns, withers and dies. Department of Biology scientists are determining if Labyrinthula, a slime mold that lives on eelgrass, is responsible. They have studied the protozoan's unusual means of traveling on the plant and are identifying conditions under which a normally harmless parasite might become pathogenic. Whether Labyrinthula is found guilty or innocent, the Sea Grant project has already resulted in new systematic methods for future ecological research.

In 1972 when red tides first appeared in Massachusetts waters, public officials closed all shellfish areas to avert widespread outbreaks of paralytic shellfish poisoning. Industry losses were severe. Since that time, Sea Grant researchers from the Department of Civil Engineering and WHOI have helped to identify those sites where red tides pose a health threat in order

to avoid costly mass closures. To devise even better predictive capabilities and develop control measures, Sea Grant scientists are continuing to study New England's red tide organism, Gonyaulax tamarensis. They are measuring growth rates, vertical migration, and comparing the alga's photosynthetic physiology with other phytoplankton from Perch Pond, Massachusetts, a site of recurring toxic blooms.

In Nahant Bay, decaying accumulations of another algae, Pilayella littoralis, send out noxious fumes that drive away bathers from densely populated coastal areas. Multidisciplinary researchers from MIT's Department of Mechanical Engineering, Northeastern University, the University of Massachusetts, Harvard University, Trinity College (Connecticut) and, the Marine Biological Association of the United Kingdom Laboratory and the University of Liverpool in Great Britain are looking for the causes to effect environmental modifications that eliminate the algal fouling. The scientists and engineers are combining traditional sampling techniques with computer analysis to

develop an ecodynamic model for Nahant Bay and other communities stricken by a similar problem.

Boston Harbor is physically and politically divided into an inner harbor and an outer harbor; the outer harbor stretches from the tip of Revere to the tip of Hull, and the inner harbor is represented by the densely populated Boston metropolitan waterfront area. Some areas are being redeveloped, while others remain disused. Recreational areas except for the waterfront park are rarely found. To understand and lay the foundations for improving the harbor's future, an interdisciplinary group led by a professor from MIT's Department of Ocean Engineering is designing alternative management schemes that will enable a Harbor Commission, established by the state legislature, to efficiently and effectively handle the environmental, public access, and economic development issues that confront the revitalization of Boston's urban waterfront.

## Wastes to Resources

Management is a word prominently mentioned in Sea Grant's mandate. Most frequently it is associated with fisheries quotas, land-use planning, balancing offshore costs and risks. But it can also be related to wastes -- their treatment and use. MIT's Program has concentrated recently on transforming materials destined to be thrown away into new or recycled raw materials.

One of the ocean's least popular creatures may contain substances that are useful in controlling some kinds of blindness and tumors. A shark's huge endoskeleton is almost entirely composed of cartilage, which laboratory tests have identified as a source of biochemicals that inhibit unwanted blood vessel proliferation. Sea Grant studies in the Department of Nutrition and Food Science and at Boston's Children's Hospital will isolate those biochemicals in the shark which could have important medical applications in vascular medicine.

Another project in the Department of Nutrition and Food Science may help turn a shellfish waste into a new source of food. Chitin, a long polymer similar to cellulose, is abundantly available in the crab, lobster and shrimp shells now thrown away by seafood processors once the meat has been extracted. Scientists are creating a food matrix from chitosan, a derivative of chitin, to simulate cheese, bread and fish products. These foods could be made without ingredients that spur allergic reactions in some people. Bread made without gluten is one example. In the case of fabricated fish, the matrix might allow processors to use edible wastes, such as muscle tissue, or underutilized species to replicate popular seafood dishes.

Polluted dredge spoils may be the source of profit for companies now having trouble finding places to dispose of them safely. Researchers in the Department of Chemical Engineering believe that water brought to near critical conditions could sanitize the materials into clean sand and clay products. At the same time the contaminants, heavy metals and organic materials like oil, could be recovered and remarketed as raw materials.

Treated sewage sludge shows commercial potential as a fertilizer for aquaculture systems. But irradiation and conventional methods that destroy pathogens and bacteria are unable to remove trace elements, and some question remains whether these materials might accumulate in organisms as they are absorbed upward in the food chain. Scientists from MIT's Nuclear Reactor Laboratory and the New England Aquarium are quantifying this uptake and estimating how to mix seawater and sludge in safe and efficient brews for nourishing aquaculture systems of phytoplankton, brine shrimp, and juvenile fish.

## Offshore Resources

New technologies are needed to look for and extract oil and other minerals from the ocean floor. Platform costs rise -- and working conditions become more hazardous -- as offshore exploration moves seaward. Next year Sea Grant's researchers look for more reliable, less expensive construction and maintenance technology.

Unlike onshore exploration, where most information comes from direct observations, in offshore exploration acoustical profiling is often used to determine geotechnical properties. However, the reliability of the information is difficult to evaluate and formal models are not available. Researchers in the Department of Civil Engineering are studying the reliability of acoustical data to make inferences of layer thickness, location and continuity and to detect anomalies. A model incorporating this information will help to reduce the uncertainties of identifying subbottom properties.

Another project in the Department of Civil Engineering has combined testing procedures from new and existing instrumentation to determine soil properties at specific offshore sites. Following in situ tests off the coast of Venezuela, the researchers are continuing to calibrate offshore data with extensive information obtained onshore to complete the analytical framework for interpreting the information. Next, the Sea Grant researchers will combine two instruments into one to replace the costly and time-consuming testing such as core drilling sediment sampling used at present by the offshore industry.

With increased construction in densely traveled or ice-infested offshore areas, limiting the damage and danger of collisions becomes a concern. In the Department of Ocean Engineering, scientists have undertaken a three-year project to predict the energy absorption capability of a typical steel offshore structure and to establish a set of rules and recommendations for

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The MIT Sea Grant Quarterly Report reviews the Program's marine-related activities at the Massachusetts Institute of Technology. Free subscriptions are available on request from the MIT Sea Grant College Program, Building E38, Room 370, Cambridge, MA 02139. Telephone: (617) 253-4307.

use in establishing design criteria that would limit collision damage. In the last year of this Sea Grant project, the researchers will analyze protection technology devised for automobiles, airplanes and ships to develop appropriate and effective fender systems for offshore installations.

Department of Mechanical Engineering students and faculty are blending the talents of humans and machines for deepsea tasks. In a communications system known as supervisory control, a human operator on the surface directs an underwater mechanized subordinate designed with joints for freedom of movement and sensors for decision making. Continuing research will determine the best tradeoffs between the coworkers, prescribing human intervention for the unpredictable tasks and automation for those that can be planned.

Advances in microprocessing and communication technology have significantly broadened the potential for direct acoustical communication in the highly reverberant marine environment. Researchers from the Department of Ocean Engineering, the Department of Electrical Engineering and Computer Science, and Woods Hole Oceanographic Institution are encoding digital data through frequency shift keying of acoustic signals. Acoustical telemetry promises to free remotely controlled vehicles from the restrictions of a communications tether.

Everything is being made instamatic these days. Cameras take perfect pictures every time, televisions focus at the touch of a button. Sea Grant researchers in the Department of Ocean Engineering are packaging underwater welding techniques into cassettes that can be used by divers with no welding experience or by remotely controlled robots. The technology will be safe, simple and economical for ship repair, offshore structure maintenance, and underwater salvage operations.

Large waves resulting from strong winter storms wreak havoc with coastal and offshore structures. As the waves approach the shore, energy is supplied to the wave motion from the wind. Some of that energy is lost through wave breaking (white caps) and, in shallower water, through interaction with the bottom (bottom friction). The roughness of the ocean floor controls the amount of energy lost. And the wave motion by itself can change a flat sand bed to a rougher, rippled surface. Sea Grant research in the Department of Civil Engineering is developing a rational procedure to predict wave-generated seabed forms and the resulting energy dissipation.

The information will be incorporated into wave forecasting models to establish sound efficient design criteria for strengthening offshore structures against the battering of hostile storm waves.

## Technologies for Ocean Uses

Projects in this Sea Grant category address the application of new and improved technologies for a range of uses. Though unrelated specifically, the research shares the common aim of promoting the development of ocean resources in a manner that is beneficial to society as a whole.

When an oil spill occurs there is little time to choose the most efficient clean-up equipment, locate it, transport it and estimate the costs of clean-up, impact and damage. Ocean Engineering professors are leading an industry-academic research team to develop two problem-solving oil spill models. One will evaluate alternative clean-up strategies; the other, locate emergency equipment for small-to-moderate-sized spills. With these computer tools, it will be possible to compare the costs of clean-up with the costs of environmental damage. The models will provide an important tool for devising strategies and selecting equipment that is specific and appropriate to spill size.

In the 18th and 19th centuries, hundreds of coastal grist and lumber mills ran on tidal energy. Fossil fuel shortages have rekindled interest in using ocean sources to power small-scale industrial facilities, public utilities and isolated residential areas. A Sea Grant project in the Department of Mechanical Engineering is assessing the costs and efficiencies of small (10 kilo-watts to 1 megawatt) tidal systems and estimating their affect on marine ecosystems.

In the Department of Ocean Engineering, single integral equations are being tested and applied to various ship designs to solve an old problem -- to decrease drag from wave resistance. Maritime industries, with more efficient hull shapes, could reduce fuel costs or make faster and more efficient oceanic trips. Ships with a reduced wake will also cause less disruption when they travel in crowded coastal waters.

A fiberglass recreational boat with an unblemished surface may actually contain hidden flaws which could cause a break-up at sea. In the Department of Mechanical Engineering, researchers are developing a simple cost-effective technique employing liquid crystals heated to controlled temperatures to reveal and evaluate the depth, thickness and composition of fiberglass flaws. The results will be of use to boat manufacturers for maintaining quality control, to government agencies for establishing structural safety criteria, and to marine surveyors for estimating the insurability of used boats.

## Advisory Services

The three components of MIT Sea Grant's advisory services specialize in technology transfer. They monitor the concerns of the marine community and then make sure that problem-solving technology or information gets to the public once the research is complete.

Four times a year representatives from government and industry come together at a Marine Industry Advisory Service (MIDAS) workshop to discuss Sea Grant research in progress. The 112 member organizations of the MIDAS Collegium receive a brief before each meeting that summarizes business opportunities inherent in one or a series of related projects. Talking with faculty and students, industry and government representatives are able to suggest how the research can be best focused for their uses and share information and data that is important to university engineers and scientists.

A newsletter initiated last year by MIDAS and jointly sponsored by Sea Grant and the Office of Ocean Engineering in NOAA reports on many non-Sea Grant projects at universities throughout the country.

In New England, the Massachusetts Marine Liaison Service (MMLS) offers specialized help to state and regional industries and citizens. Two prominent concerns over the past years have been coastal erosion and fishery technology development. Working with coastal communities and state agencies, the Marine Extension Service, under MMLS and University of Massachusetts Cooperative Extension guidance, will provide advisory coverage and technical assistance to Massachusetts coastal communities.

A joint project with the Massachusetts Maritime Academy has established a fisheries education program. In the coming year, courses geared to the nearshore and offshore fishermen will be held in part on a newly renovated fisheries training vessel equipped with modern rigging and hydraulics.

Sea Grant's publisher is the Communications/Information Service which produces about thirty reports a year on the results of the Program's research. The Quarterly Report, special directories, and magazine articles are also vehicles for keeping the public informed on ways Sea Grant can help. A small public reference facility, the Marine Resources Information Center, maintains a collection of marine journals, reference materials and reports from all Sea Grant's 28 programs.

## Education

Developing marine resources is not limited to instrumentation and modeling. There is a human side as well. A broad spectrum of MIT's program activities train professionals for ocean-related careers and encourages the public to learn more about water, a substance that is not only essential to all life on our planet, but that is also largely underutilized as an educational tool.

During the Independent Activities Period in January, MIT undergraduates acquire practical ocean engineering research experience by conducting experiments in an ocean environment. During the remainder of the academic year, laboratory work gives them the opportunity to collaborate with Institute faculty members on technology development.

Sea Grant [illegible]evisions in ocean eng[illegible]urricula to reflect the [illegible]ing state-of-the-art in that field. Each year, special studies in systems engineering engage upperclassmen and graduate students in a complex, "real world" problem of current interest that requires input from a number of disciplines. This year, the technical, engineering, economics and environmental considerations of using coal for ship propulsion will be studied.

Working professionals come to MIT each summer to take special short courses designed to give them insights into new techniques, developments and technical progress resulting from research at the Institute. In the marine field, Sea Grant cooperates in sponsoring courses that will aid managers, scientists and engineers concerned with ocean development.

Another education project this year continues to develop marine science materials for teachers of students in kindergarten through the twelfth grade. A tapestry of experiments, tested in New Bedford's summer Sea Lab, is being constructed to build scientific skills, encourage observation and documentation and foster an appreciation of water's varied and extraordinary properties.

College students from MIT and other universities in the Boston area study the impact of water on their lives. In a course planned by a citywide consortium, undergraduate students are brought "Into the Ocean World" to explore how water has affected and is continuing to affect history, economics, industry, literature, art and music. Teachers from several schools combine their talents and knowledge to show how human activities interact now and in the future with the world of water.

Every year the Sea Grant Program sponsors a public lecture and symposium to explore an issue that affects policy and the direction of marine resource development. Ronald C. Lassiter, President of Zapata Corporation, will deliver the Ninth Annual Sea Grant Lecture, GEORGES BANK: FISH AND FUEL. Ira Dyer, Head of MIT's Department of Ocean Engineering, will moderate a panel that represents different points of view on how to use the Bank for energy and food.

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# Abstracts

## ☐ Suggestions for the Revitalization of the Village of Hyannis

Lisa T. Rosenbaum
William W. Seifert
MITSG 79-21 173 pp. $5.00

The village of Hyannis has, since the early development of Cape Cod, Massachusetts, been regarded as the commercial center for the Cape. This report, produced by an MIT undergraduate interdisciplinary design systems class, addresses problems noted by concerned residents, business people, and tourists in Hyannis Harbor and the surrounding downtown area. The report examines some specific suggestions for new development options, presents some ideas to planners for revitalizing older, but viable town facilities, and offers thoughts on the planning process itself.

## ☐ Prediction of the Damping-Controlled Responses of Offshore Structures to Random Wave Excitation

J. Kim Vandiver
MITSG 80-9J 10 pp. $1.00

This paper introduces a simple procedure for estimating the dynamic response of a structure at each of its natural frequencies to the random excitation of ocean waves. For many structures it is possible to derive a simple expression for the wave force spectrum in terms of radiation damping and the prescribed wave amplitude spectrum. The principal advantage of the proposed method over those currently applied is that the explicit calculation of wave forces is not required in the analysis. Several example calculations are presented and directional distribution of the wave spectrum is included in the analysis. Journal reprint: Society of Petroleum Engineers Journal, 1980.

## ☐ Marine-Related Research at MIT

Compiled by
Barbara Steen-Elton
MITSG 80-10 60 pp. No charge

MIT has long pursued answers to marine related issues--the first Department of Ocean Engineering was established at MIT in 1883. Research sponsored at MIT, not only by the National Sea Grant Program but throughout various departments, is listed in this annual directory according to topic: Coastal Zone Ecology, Management and Coastal Processes; Education; Energy; Fisheries and Living Resources; Marine Mineral Resources; Ocean Engineering Acoustics, Hydrodynamics, Instrumentation, Materials, Offshore Structures, Ship Structures; Oceanography, Marine Chemistry, Marine Geology, Physical Oceanography; Pollution; Transportation; and Water Resources. A subject index and an author/principal investigator index are included.

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## ☐ An Assessment of Undersea Teleoperators

Thomas Nico Sofyanos
Thomas B. Sheridan
MITSG 80-11 315 pp. $8.00

This extensive report, prepared as a thesis in MIT's Department of Mechanical Engineering, assesses the current and near-future applications of undersea teleoperators and competing methods of underwater intervention. General purpose submersible work vehicles, remotely controlled by human operators, offer cost and safety improvements for scientists, industry and the military. The report is a well-documented compendium of information and representative costs for offshore divers and manned and unmanned submersibles. It identifies the role of remotely operated vehicle systems and their potential effect on diving safety and offshore installation inspection. Current development trends for teleoperator systems are examined and federally supported programs are evaluated.

## ☐ Pore Pressure During Cone Penetration in Clays

Jacques-Noël Levadoux
Mohsen M. Baligh
MITSG 80-12 310 pp. $8.00

This report discusses in situ and laboratory analysis of pore pressure during cone penetration in clays. Using the strain-path method to investigate the mechanism of cone penetration and estimate pore pressures, the results are combined with specially developed soil behavior models and known strain paths of soil elements which determine deviatoric stresses and sheer-induced pore pressures. The comparisons attempt to explain deviation in results between tests performed in different deposits. The results are then applied to questions about soil stability and compressibility with deep penetration, pile installation, and undrained loading problems in offshore construction.

## ☐ Pore Pressure Dissipation after Cone Penetration

Mohsen M. Baligh
Jacques-Noël Levadoux
MITSG 80-13 368 pp. $8.00

Using relatively new conical piezometers with a very rapid response time, researchers at MIT have been evolving new analytical methods to determine soil properties directly at offshore sites. This report describes the new equipment and the methods of estimating consolidation and permeability characteristics of fine-grained soils from measurements of the pore pressure decay after cone penetration is interrupted. A new, economical and consistent method for examining the coefficients of consolidation and permeability is evaluated using extensive dissipation measurements in two clay deposits. The predicted profiles provide good agreement with laboratory data and full-scale performance.

## ☐ The Design, Construction and Development of a Prototype Machine for Processing Spiny Dogfish Shark

William B. Hoff, III
David Gordon Wilson
MITSG 80-14 58 pp. $3.50

New sources of food require new technologies for efficient production and minimal waste. Machines used to process popular fish such as cod and flounder were unsuitable for the more rounded, tough skinned spiny dogfish shark--an unappreciated but abundant fish found in both the Atlantic and Pacific. This report describes an advanced prototype machine with pneumatically actuated parts and a solid-state, programmable controller, for processing the spiny dogfish. The process follows the steps used by hand labor, but the time required to process a fish by machine is now approximately 12 seconds, less than half the time of hand laborers. With simple developments in future machines, the time could be considerably reduced. The development of this machine could make the spiny dogfish and other fisheries economically attractive.